Health Monitoring and Management System by Using Wireless Sensor Network and Internet of Things (IoT)

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Summary
Recent advancement in wireless sensor network (WSNs) and the Internet of Things (IoT) made the life easy especially in the field of monitoring and controlling the events of life. As a result of this advancement in technologies give the concept of providing integrated services almost in all the field but it help lot in the field of health care services. A body sensor network emerged very vital for monitoring and managing health care services by using Internet of Things (IoT) embedded with sensory system in last couple of decades. In this research work the autonomous system of sensors are defined and a framework is proposed to measure various vital signs for monitoring purposes. The proposed system is capable to monitor human body blood pressure, heart rate and temperature, etc. The sensor system communicate the sensed information to the base controller by using IoT where it will be analyzed with patient history and the alert is generated to inform the concerned department. The expert take the decision based on the medical history of the patient and then rescue team will be instructed to rescue the cross ponding patient. In case of the heart patient the information will be very critical as the proposed system is capable to detect condition of the patient well before the heart attack. A detailed analysis and performance of proposed framework for health care is presented in this paper. The presented analysis indicates that the proposed system can be implemented by using the hardware units for the purpose of monitoring and managing the patient who is under supervision of the rescue team.

Key words:
Internet of Things, Wireless Sensor Networks, Wireless Body Area Network, Medical Super Sensor, photopletysmograph

1. Introduction

Particularly in emergency situation the patient monitoring system play the vital role to maintain the patient vital signs. There is lot of IoT application in the hospital to deal with various issues like injection to the patients of any drug by doctor from remotely, monitoring patient's heart beats, sugar level by the concerned doctors.

The increased use of electronics and mobile technologies, it makes the easy to monitor and manage patients remotely by using Internet of Things (IoT). With the increasing number of things on the internet the concept of providing integrated services as a result of communication amongst heterogeneous networks is gaining momentum. Internet of Health (IoH) is a byproduct of all those efforts. Health experts are benefiting from the technology and embedding it with health monitoring system to manage the patients remotely. Patient health monitoring by using IoT along with smart sensor system is enable the health expert to monitor the patient from office, home or anywhere from this globe. WSN's are very promising for monitoring extraordinary diverse environments. A WSN consists of wireless nodes that are able to sense some physical information, process and transfer to the destination by establishing wireless ad-hoc networks. The sensor system comprised of tiny sensor nodes which are capable to sensor a phenomenon, process the sensed information and communicate with its neighbors [1]. The use of WSN dramatically increased in electrical and electronic equipment in the field of medical research and clinical purposes in the last quarter of a century. In medical devices, the main function is to measure or determine the presence of a physical quantity that can be useful for diagnostic purposes. In hospital and physician's clinic many different type of instrumentation systems are used for various treatments. The basic purpose of the medical instrumentation is to measure the presence of some physical phenomena that may help the medical staff to make better diagnosis and treatment. Therefore, so many types of equipment is used in the medical facilities and hospitals. Any of the medical instrument would contain of the following four basic functional components: Measure and, Transducer/Sensor, Signal conditioner and display system. Patient monitoring system in all ICUs is the most needed and essential device for monitoring the patient's vitals [2]. The sensor nodes the ability to sense, process and transmit vital physiological signals using wireless technology [4]. The sensor network nodes carefully planned and installed in the prearranged positions and can be installed in an ad hoc manner which make the system robust, fault tolerance and increase in spatial coverage. The installed be can used to monitor and track the patients in cities and rural areas by using internet or intranet to reduce the stress of healthcare providers, eliminate medical errors, reduce workload, increase efficiency of hospital staff, reduce long -term cost of healthcare services, and improve the comfort of the patients [5]. To improve the life quality of the patient without interrupting the patient normal life routine, the system is capable to monitor physiological signals remotely [6].Sensor nodes can be strategically placed on the human body to create a cluster that is called wireless body area

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network (WBAN) that can be used to collect patient's vital signs [7]. The sensor nodes can be used with the smart device as mobile phones i.e. PDA, GPRS, etc. This research work is simulation based and proposes a networking solution in which Sensor (Medical Super Sensor - MSS) is used to collect multiple physiological signs sensed by nodes installed on patient body in WBAN and sent the sensed information to personal server. For this purpose an Intelligent Personal Digital Assistant (IPDA) is used as a personal server, the vital signs are sensed by the sensor system and transmit the date based on patient's current condition and data content.

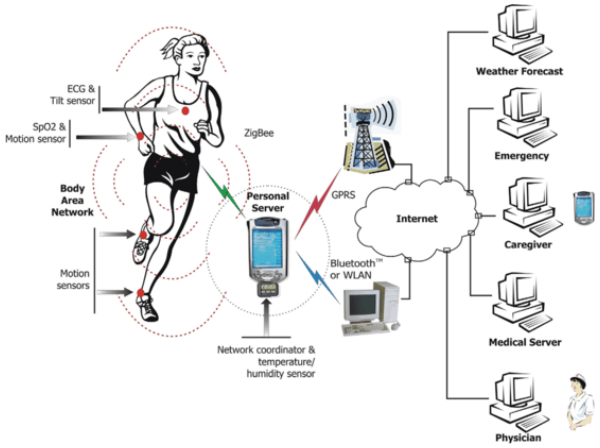

Fig. 1 Wide body area network [10]

This proposed system consists of low cost components that are capable of processing sensed data which is ECG, BP, Temperature, Heartbeat and the proposed system is capable to transmit the data to the concerned sources. There a lot demand for such a system, as exiting systems are very complex to use and costly as well. The proposed system is capable to provide the solution to encounter the existing problems and issue the alert regarding swear heart related problem. The system is capable to work independently and the patient can be monitored remotely without effecting the routine life. The major aim this research work to show how persons suffering from cardiovascular and other hypertension disease can directly monitor their vitals by using GPS, GSM modules.

2. Literature Review

In recent years' wireless sensor networks (WSN's) and Internet of Things (IoT) have strongly emerged in the medical field for healthcare of the patient for data collection regarding the physical, psychological, cognitive and behavioral processes for monitoring purposes. During the literature review, we studied and representing some applications in the healthcare field T. J. Hodgetts and K. Mackaway-Jones and G. Super, S. Groth, and R. Hook application are directed towards Monitoring in mass-casualty disasters; while triage protocols for emergency medical services already exist [8], [9], their effectiveness can quickly degrade with increasing number of victims. However, there is a need to improve the assessment of the first responders' health status during such mass-casualty disasters. In the figure below it shows that how the proposed system will work and it take all the vitals and processed the information and send it to the emergency services to initiate the alert. It is very difficult to monitor and treat the following diseases such as asthma, diabetes, high blood pressure, congestive heart failure, chronic obstructive pulmonary disease, and memory decline. These diseases can benefit from patients taking an active role in the monitoring process.

The sensor nodes can be embedded in living area or carried by the person for the purpose of the collecting information about the physiological, personal and behavioral states and patterns in real time situation. The authors of [3, 4, and 5] adopted PPG in their design. The researchers [4, 10] presented their idea of a device under development to monitor the cardiovascular status of patients. It is used to monitor the cardiovascular status of patients.

Fig. 2 Body area and communication network [10]

It stores all recorded physiological signals (ECG, PPG photopletysmograph) for medical post-processing. They also suggested that the family doctor may be notified by a text message sent automatically to the case of the critical value of the parameter measured occurs. However, no other results of this research will be presented. A practical system for monitoring heart rate, he does not use the auto-counting of blood or ECG signal pulse is generated [5, 12]. The sensor output is viewed by the number of hours of counting the counter display using the 7-segment display. An updated result in counter display for reading it every two seconds.

Heart rhythm method is adopted in the development of this project. The main purpose of developing systems [3, 11] has developed a heart rate monitor with wireless transmission to a receiver that displays the heart rate in beats per minute. It uses Bluetooth technology to communicate data to a computer terminal. The disadvantage of this system is the distance between the computer and the sensor is not more than 20 meters, which does not seem practical to implement.

3. Research Methodology

The proposed algorithm constantly monitor body parameters e.g. heartbeat, temperature and blood pressure and compare it against a predetermined value set. If measured values are higher than described limit then the system automatically send the alert the doctor by using Internet of Things (IoT). In such case the patient get a very quick medical help and also save time to get first aid as required. In the proposed algorithm the heart patient is considered as highest priority for data comparison and analysis. The heart patient who have the medical history like they have heart attack before, the system detect heart health based on the current and previous data, after data analysis the system automatically call the emergency service and the affected person will be rescued before some medical condition. The rescue services provide him the first aid on the spot before transferring to hospital for further treatment. The proposed system automatically transmit the data to the base by using Internet of Things (IoT), where experts will take decisions. The proposed system enable medical professionals to monitor and manage patients remotely by using various technological devices along with Internet of Things (IoT). In the figure below the proposed algorithm is given

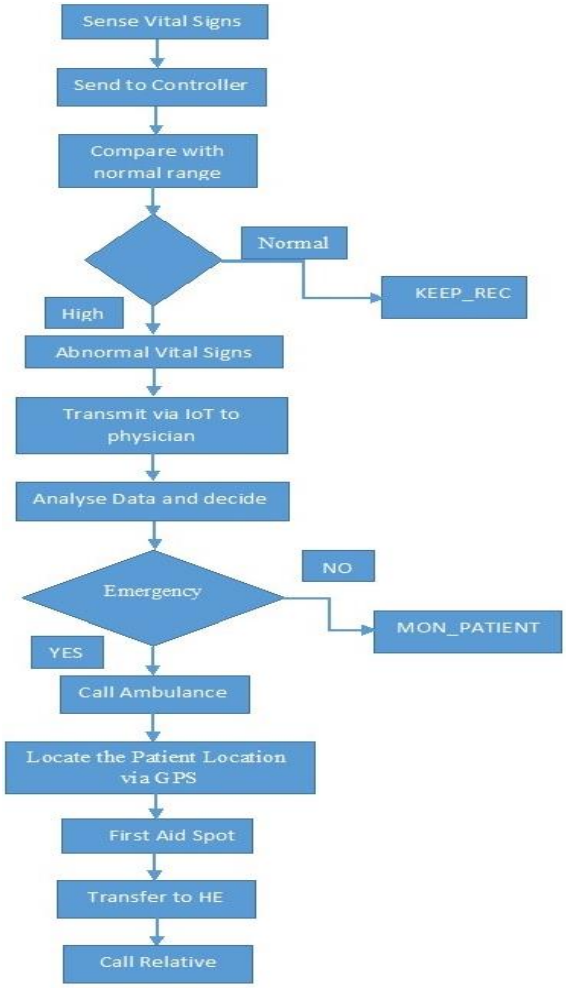

Fig. 3 Proposed Algorithm to monitor and manage the patient

4. Proposed System Modules

Following modules are the key part of the proposed system to monitoring and manage the patient

a) Blood Pressure Sensor

Blood pressure sensor unit is used to measure the arterial blood pressure flowing through the blood vessels against the walls of the arteries. The pressure signals are measured produced by the interaction between the cuff and the blood flow over the brachial artery. The blood pressure depend on the flow of the blood, if the is normal flow then blood pressure is normal (120/80), but if there is problem in the blood flow the pressure goes up. If high blood pressure goes undetected, the person is at risk of severe medical problems. Figure below shows the blood pressure category

Blood Pressure Category	Systolic mm Hg (upper #)		Diastolic mm Hg (lower #)
Normal	less than 120	and	less than 80
Prehypertension	120 – 139	or	80 – 89
High Blood Pressure (Hypertension) Stage 1	140 – 159	or	90 – 99
High Blood Pressure (Hypertension) Stage 2	160 or higher	or	100 or higher
Hypertensive Crisis (Emergency care needed)	Higher than 180	or	Higher than 110

Fig. 4 Blood pressure category [10]

b) **Temperature Sensor**

This unit measures the temperature of patient and it also known as analog temperature sensor. The output voltage is linearly proportional to the temperature in Celsius and to measure the body temperature solid state technology is used. If the temperature increases mean voltage also increases. The analog signal is generated due the change of voltage that is directly proportional to temperature.

c) **Heart Beat Rate**

A sensor unit is integrated in wrist band and it is weared by patient in left wrist and it measures the heart beat by using the defined interval and send it to the central unit where it is processed. At central unit it is saved and compared with the standard and previous measurement, if it finds any abnormality in the heart beat then it reported to concerned system and issues an alert.

Resting Heart Rate Chart

Men (beats per minute)

Age	18 - 25	26 - 35	36 - 45	46 - 55	56 - 65	65 +
Athlete	49 - 55	49 - 54	50 - 56	50 - 57	51 - 56	50 - 55
Excellent	56 - 61	55 - 61	57 - 62	58 - 63	57 - 61	56 - 61
Great	62 - 65	62 - 65	63 - 66	64 - 67	62 - 67	62 - 65
Good	66 - 69	66 - 70	67 - 70	68 - 71	68 - 71	66 - 69
Average	70 - 73	71 - 74	71 - 75	72 - 76	72 - 75	70 - 73
Below Average	74 - 81	75 - 81	76 - 82	77 - 83	76 - 81	74 - 79
Poor	82 +	82 +	83 +	84 +	82 +	80 +

Women (beats per minute)

Age	18 - 25	26 - 35	36 - 45	46 - 55	56 - 65	65 +
Athlete	54 - 60	54 - 59	54 - 59	54 - 60	54 - 59	54 - 59
Excellent	61 - 65	60 - 64	60 - 64	61 - 65	60 - 64	60 - 64
Great	66 - 69	65 - 68	65 - 69	66 - 69	65 - 68	65 - 68
Good	70 - 73	69 - 72	70 - 73	70 - 73	69 - 73	69 - 72
Average	74 - 78	73 - 76	74 - 78	74 - 77	74 - 77	73 - 76
Below Average	79 - 84	77 - 82	79 - 84	78 - 83	78 - 83	77 - 84
Poor	85 +	83 +	85 +	84 +	84 +	85 +

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Fig. 5 Heartbeat according age group

d) **GPS Module**

The Global Positioning System (GPS) module is a satellite navigation system that can be used to locate the positions anywhere on the globe. Designed and implemented by the Defense Department of the United States, which includes satellites, control and monitoring stations and receivers. GPS receivers receive training transmitted by satellites and uses triangulation to calculate the user's exact GPS location. This unit is very important to rescue the patient, by using the GPS, rescue services easily locate the affected person.

5. Proposed System

The proposed framework for the health management and monitoring by using IoT is given in the figure below, which is composed of the patient unit including the sensing unit for the acquiring patient vital signs. The proposed system measure the patient the value of Blood Pressure, Temperature and Heartbeat is saved from below and above normal values. Critical range is defined based on the patient and in emergency situation. The proposed model is capable to process the data locally and if it finds some uneven reading, above or below of defined range. The system automatically increase the frequency of the measurement of the patient under monitoring.

If the patient under monitoring has continually high blood pressure and has the sign of heart problem and the system generate the alert to the concerned authorities. The generated alert is assessed by concerned department on priority bases and further action is suggested. After assessment, if the patient need to transport into hospital for further assessment and treatment.

In the figure below the working of the proposed system is presented. The proposed system comprised on various components working under the following modules named as patient unit which is installed on the patient body take the measurements. The measured data is processed and transmitted to the controller and database server where it is analyzed and decision is made for further actions. The patient unit consists of the temperature sensor (Temp_Sen), blood pressure sensor (BP_Sen) and heartbeat sensor (HBR_Sen). Theses sensors measures the vital under the given period and if it finds some critical information form newly sensed information then it reduce the time between the measurement. Then patient is put under care by patient unit and if needed then system initiate the alert to the monitoring system as shown below

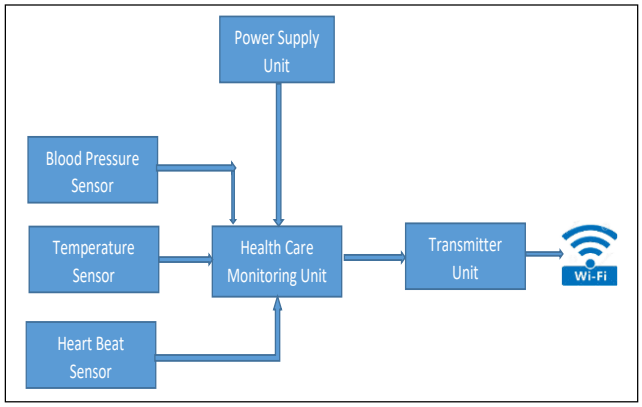

Fig. 6 Patient unit with receiver and controller

If the information is critical then it sends the information to receiver unit and that is processed at the controller. A decision is made at the controller based on patient history to initiate emergency to the concerned department and sending the information, the system send the location of the patient by using GPS module as shown below in the diagram.

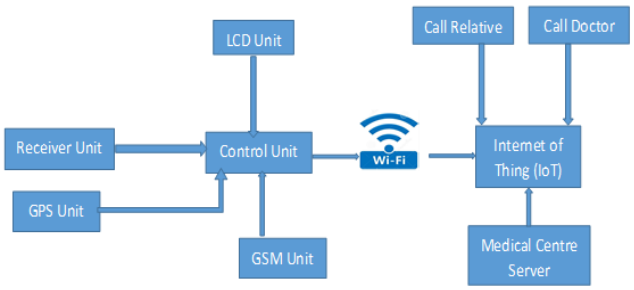

Fig. 7 Management unit with receiver and controller

When the rescue team reach at the location to give first aid on the scene and officer will assess the patient condition, either need to transfer to hospital or not.

In the figure below it explains the working of the proposed system for patient monitoring which include the various components to monitor and manage the patient under observation. The communication between different components is based on IoT, GPS and GSM modules

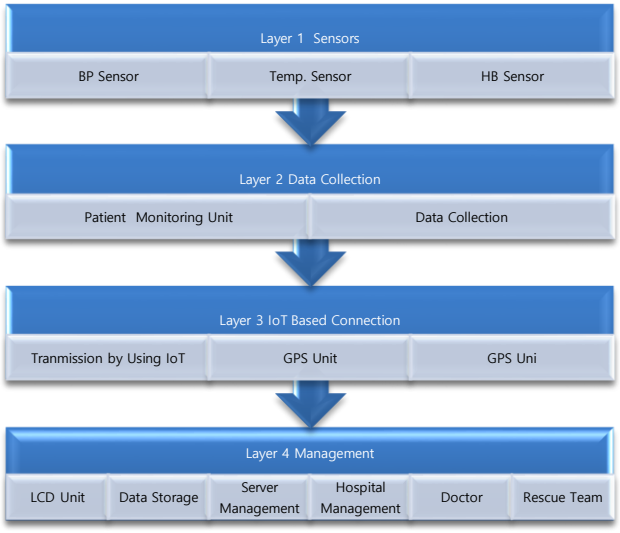

Fig. 8 Framework of proposed model

The sensing modules measures the vitals (BP, Temp., HB), the fetched vitals are processed and transmit to the base station where it is analyzed and critical value saved against the patient. If the measurements are within normal range then it is saved and no action is taken but if it is falls outside the normal then the measurement frequency is increased. The patient put under continues observation for some hours and the generated data is still falls outside the normal, the alert is generated to rescue then it is assessed against the history of the patient, if the patient have heart disease history then it put under critical care until next measurement. If the measured data is coming continuing outside the normal range then by the GSM module send the message to concerned department. The patient location is also shared by GPS module to guide the rescue team to reach the location. At the scene rescue team assess the condition of the based on the history and current situation and if needed then transported to the hospital for further treatment.

6. Conclusion

This research work addresses the issue of rescuing a patient in case of emergency along with tracking and monitoring the patient in emergency situation to provide the necessary medical treatment and transfer to the hospital. The vitals of the patient under investigation taken through the patient unit of the proposed system and processed at patient unit. If the processed information is critical and shows the sign of emergency then this information immediately transmit to the base station for further investigation. The fetched information is analyzed and further action are suggested. In case of heart patient, initial alert message is generated to alert the concerned department. If there is continuity in the

uneven data then GSM module initiate call to the emergency number and also send the current location of the patient to rescue for treatment by GPS module with the support Internet of Thing (IoT). In case of severe case the alert is generated and the patient rescued from the location which is provided through the GPS module.

Future Work

The first direction of enhancement of this work is to implement the proposed algorithm by using prototype in next step. The system will be designed by using ZigBee sensors to extract patient vitals and processed at controller to predict current conditions. GPS modules will be used for location tracking and GSM module will be very used to call and generate emergency messages and calls.

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